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(54)Title of the Invention

# IMAGE COMPRESSION / DECOMPRESSION APPRATUS FOR SELECTING FREQUENCY DISTRIBUTION DEPENDING ON DEGREE OF DISPERSION IN GRADATION VALUE AROUND ENCODED PIXEL

(57)Abstract

[Problem to be solved]

In the prior art, a distribution of prediction difference is regarded as mere one frequency distribution. However, in fact, the frequency distribution of the prediction difference differs depending on degree of dispersion in gradation value of pixel around encoded pixel. A coding information amount is reduced by reflecting the fact in coding / decoding of the prediction difference.

[Means for solving the problem]

In an image compression apparatus and an image decompression apparatus, one frequency distribution table is selected from among a plurality of frequency distribution tables on the basis of dispersion index which is generated by quantifying the degree of the dispersion in the gradation value of the pixel around the encoded pixel, and it is used for coding / decoding of the prediction difference. Or, appearance probability is analogized by performing calculation of integration value of probability density function which provides the different frequency distribution for each dispersion index, and it is used for the coding / decoding of the prediction difference.

[CLAIMS]

1. An image compression apparatus comprising:

a device for calculating dispersion index which indicates degree of the dispersion in a gradation value, from the gradation values of plurality of pixels around encoded pixel; and

a plurality of frequency distribution tables which is selected by the calculated value,

one frequency distribution table being selected on the basis of the dispersion index and being used for encoding of prediction difference.

2. An image decompression apparatus comprising:

a device for calculating dispersion index which indicates degree of the dispersion in a gradation value, from the gradation values of plurality of pixels around encoded pixel; and

a plurality of frequency distribution tables which is selected by the calculated value,

one frequency distribution table being selected on the basis of the dispersion index and being used for decoding of prediction difference.

3. An image compression apparatus comprising:

a device for calculating dispersion index which indicates degree of the dispersion in a gradation value, from the gradation values of plurality of pixels around encoded pixel; and

a device for calculating integration value of probability density function which provides the different frequency distribution for each dispersion index,

calculation result being used for encoding of prediction difference.

4. An image decompression apparatus comprising:

a device for calculating dispersion index which indicates degree of the dispersion in a gradation value, from the gradation values of plurality of pixels around encoded pixel; and

a device for calculating integration value of probability density function which provides the different frequency distribution for each dispersion index,

calculation result being used for decoding of prediction difference.

[DETAILED DESCRIPTION OF THE INVENTION]

[0001]

[TECHNICAL FIELD TO WHICH THE INVENTION BELONGS]

The present invention relates to a gradation image compression apparatus and a gradation image decompression apparatus for looking on a gradation image as a group of pixels and for encoding the prediction difference for each pixel.

[0002]

[Background Art]

The method for entropy-encoding on the basis of frequency

distribution of difference between a value (called as "prediction value") which is predicted from gradation value of one or more pixel (called as "reference pixel") which are already encoded out of pixels around pixels (called as "encoded pixel") which are desired to be encoded and the gradation value of the encoded pixel is used, in the image compression apparatus for looking on a gradient image as a group of pixels and for encoding the pixel one by one in the order such as television scan. For example, JPEG is disclosed in ISO/IEC 11544, "Progressive Bi-level Compression Standard", 1993. Frequency distribution can be obtained as a form of frequency distribution table which is obtained by counting up an appearance time for each prediction difference value, and is used by an entropy encoder. The reference pixel for predicting the prediction value may not be obtained adequately, on the periphery of the image, however, some exceptional process can be added to a method of predicting the prediction value and a method of obtaining the reference pixel.

[0003]

Decompression of the image is performed by repeatedly decoding the pixel one by one in the order same as in the case of the compression. Each pixel (called as "decoded pixel") which is desired to be decoded, the prediction difference same as in the case of decoding can be obtained by an entropy decoder. Moreover, the prediction value can be calculated from the decoded pixel which is already decoded, and is same as in the case of decoding. The gradation value can be obtained by adding both. The image can be decompressed by repeating this process. Moreover, instead of the

method for using the frequency distribution of the prediction difference, a method for resolving probability density function is also known. This method is disclosed in TANAKA Syoichi, "Optimum Coding of Signal which is in Laplace distribution", Institute of Electronics, Journal of Information and Communication Engineers (IEICE), Vol. J65-A No.4, April 1982 and SAITO Tsuneo, "Image Compression Algorithm", Kindai Kagaku sha Co., Ltd, 1993. The probability of the predict difference becoming a certain value is analogized from the distribution of the prediction difference by using the probability density function or its integration function, and the prediction difference is entropy encoded on the basis of the analogized probability. An arithmetic encoding method , a Huffman encoding method, or the like is used as the entropy encoding method. In compressing color image, the image compression can be achieved by applying the above process for each element data which constitutes color.

[0004]

[PROBLEM TO BE SOLVED BY THE INVENTION]

In the case of regarding the plurality of neighborhood pixels (i.e. pixels around the encoded pixel) as the reference pixel, if the frequency distribution of the prediction difference is minutely obtained depending on degree of dispersion of the reference pixel, all frequency distribution has a peak on a position in which the prediction difference is 0, however, an aspect of the distribution greatly differs depending on the degree of the dispersion of the reference pixel. The aspect of the distribution is steep if the

dispersion is relatively small, and the aspect of the distribution is smooth if the dispersion is relatively large. Since the Background Art does not consider this, groups the frequency distributions whose aspects are different from each other and merely regards them as one frequency distribution related to the prediction difference, unnecessary increase of encoded information amount occurs. Same is true in the method of resolving the probability density function.

[0005]

The present invention is a method of encoding while storing frequency information of the prediction difference for each aspect of the dispersion and selectively using the frequency information depending on the aspect of the dispersion, as a method of considering not only the frequency information of the prediction difference but also the dispersion of the gradation value of neighborhood. The present invention provides a method of preventing unnecessary information amount from occurring by reflecting the fact that the distribution of the prediction difference is different depending on the dispersion. In order to obtain prediction value of the encoded pixel and dispersion index which indicates the degree of the dispersion, calculation method which realizes a fine compression rate is selected empirically. Since the present invention encodes the prediction difference on the basis of the frequency distribution of the prediction difference, the entropy encoding method such as the Huffman encoding method and arithmetic encoding method is used as encoding method.

[0006]

[MEANS FOR SOLVING THE PROBLEM]

In an image compression apparatus and an image decompression apparatus, one frequency distribution table is selected from among a plurality of frequency distribution tables (called as "frequency distribution table group") on the basis of the dispersion index of the gradation value which is calculated from the gradation value of the reference pixel, and it is used for coding / decoding of the prediction difference. Moreover, the dispersion index is calculated from the gradation value of the reference pixel, appearance probability is analogized by performing calculation of integration value of probability density function which is different for each dispersion index, and it is used for the coding / decoding of the prediction difference. The dispersion index quantifies the degree of the dispersion in the gradation value of the pixel around the encoded pixel and can be obtained from the gradation value of the plurality of reference pixels. A value indicating Difference between a maximum value and a minimum value, a value indicating variance, a value indicating standard deviation and the like are used as the value. Furthermore, a value which is obtained by function-calculating these values can be used. An average value of the gradation value of the reference pixel, an average value of a maximum value and minimum value, a weighted average value and the like are used as the prediction value.

[0007]

[EFFECT]

In claim 1, by preparing the plurality of frequency tables of

the prediction difference and selectively using these tables depending on the dispersion index, it is possible to encode the prediction difference while reflecting each of frequency distributions which are different from each other depending on the dispersion. As one example, in the case where an absolute value of difference between the gradation value of left pixel and the gradation value of top pixel is used as the dispersion index, the method in claim 1 can reduce the entropy by about 5% on autol of the SIDBA standard image, compared to the entropy of the mere frequency distribution in the conventional method. In claim 3, by using the probability distribution function in which the dispersion index is used as parameter or the integration function of the probability distribution function, it is possible to encode the prediction difference while reflecting that the aspects of the frequency distributions are different from each other depending on the degree of the dispersion.

[0008]

[EXAMPLE]

[EXAMPLE1]

A frequency distribution table group 12 is prepared with respect to the image of 256 tones (gradient). The frequency distribution table group 12 includes 9 frequency distribution tables, each of which has a size of 511 elements which can respond to 511 cases being between -255 and +255 obtained by transforming the prediction difference into integer. The dispersion index is indicated by the integer from 0 to 8. There is provided with a frequency distribution table selecting device 10 which selects one frequency

distribution table from among the frequency distribution table group 12 on the basis of this dispersion index. Counting values of all elements included in the frequency distribution table group are set to 1 in advance. For compression the image, the encoding of the pixel of compression subject image data is performed one by one in the order such as television scan, as follows. The gradation value x of the encoded pixel, the gradation value a of the pixel located on the left side of the encoded pixel and the gradation value b of the pixel located on the upper side of the encoded pixel are extracted. The dispersion index r is set to one value of 0 to 8, depending on which one range of 0, 1, 2 to 3, 4 to 7, 8 to 15, 16 to 31, 32 to 63, 64 to 127 and 128 to 255 indicates the value of $|a-b|$. The prediction value e is set to a value which is obtained by truncating (rounding) the value of (a+b)/2. The prediction difference d is calculated as x-e by a difference circuit. If there is not exceptionally the pixel located on the left side of the encoded pixel, the gradation value a is set to the gradation value of the pixel located on the further upper side of the pixel located on the upper side of the encoded pixel, in a reference pixel gradation value extracting device 6. If there is not the pixel neither, the gradation value a is set to 255. If there is not exceptionally the pixel located on the upper side of the encoded pixel, the gradation value b is set to the gradation value of the pixel located on the further left side of the pixel located on the left side of the encoded pixel. If there is the pixel neither, the gradation value b is set to 0.

[0009]

One frequency distribution table is selected from among the frequency distribution table group 12 on the basis of the dispersion index r. The prediction difference d is entropy encoded by using the selected one frequency distribution table. After referring the frequency distribution table, a frequency distribution table updating device 11 increases the element of the frequency distribution table, which is specified on the basis of the dispersion index r of the encoded pixel and the prediction difference d, by one. For decompression of the image, the decoding of the pixel of the compressed image data is performed one by one in the order same as in the case of the encoding, as follows. The gradation value a of the pixel located on the left side of the decoded pixel and the gradation value b of the pixel located on the upper side of the decoded pixel are extracted. The dispersion index r and the prediction value e are calculated, by using the same manner as in performing the encoding. One frequency distribution table is selected from among the frequency distribution table group 12 on the basis of the dispersion index r. The entropy decoder 16 obtains the prediction difference d is obtained by using the selected one frequency distribution table. The gradation value x of the decoded pixel is set to d+e. After referring the frequency distribution table, the frequency distribution table updating device 11 increases the element of the frequency distribution table, which is specified on the basis of the dispersion index r of the pixel and the prediction difference d, by one. The number and the position of the reference pixel in calculating the prediction value may be different from the number and the position

of the reference pixel in calculating the dispersion index r.

[0010]

For example, the dispersion index r may be defined as |a-b| and the number of the frequency distribution tables in the frequency distribution table group may be set to 256. However, since the increase of the counting value data of the frequency distribution table for each dispersion index is effective for the compression rate, it is preferable that the number of the frequency distribution tables in the frequency distribution table group is properly reduced. Instead of setting the initial value of the all elements included in the frequency distribution tables to 1, by setting the initial value such that the distribution has a peak on a position in which the prediction difference is 0, it is possible to assist the learning of the frequency distribution and to increase the compression effect. By degenerating the prediction difference, it is possible to realize lossy compression. The arithmetic encoder needs an accumulation value of the frequency distribution, in the case where the arithmetic encoding method is used as the entropy encoding method. The value can be calculated in the arithmetic encoder on the basis of the frequency distribution table. If store method using tree structure is used for storing the frequency distribution table, as Bell et al. reports in the document "T.C.Bell, J.G.Cleary, I.H.Witten: "Text Compression", Prentice Hall, 1990, especially pages 124 to 127", it is possible to greatly reduce a processing time for calculating the accumulation value. Same is true for the entropy decoding.

[0011]

[EXAMPLE2]

In order to compress the image in which each of the blue color, the green color and the read color is indicated by 256 tone, with respect to an image compression apparatus 2 of the example 1, three image data storing devices 4 and three frequency distribution table groups 12 are prepared for each color data. And a controlling device, an encoded pixel extracting device, a reference pixel extracting device, the frequency distribution table selecting device and the frequency distribution table updating device each of which functions for each encoded pixels and each color data are prepared. For this reason, a color image compression apparatus is constructed. Moreover, in order to decompress the color image, with respect to an image decompression apparatus 15, expansion related to the color data same as the expansion in the image compression apparatus is performed, and thereby a color image decompression apparatus is constructed.

[0012]

[EXAMPLE3]

With respect to the example 1, the arithmetic encoding apparatus is used as the entropy encoding apparatus 13. A variance calculating device which calculates variance $\sigma r^2$ of the prediction difference of the encoded pixel for each dispersion index r and a calculating device which calculates accumulation probability F(d) in which the distribution of the prediction difference in the variance $\sigma r^2$ is applied to Laplace distribution are prepared, instead of the frequency distribution table selecting device 10, the frequency

distribution table updating device 11 and the frequency distribution table group 12. The prediction value e is set to a value which is obtained by not truncating (rounding) the value of (a+b)/2. Two accumulation probabilities F(d+0.5) / (F(255.5-x) - F(-0.5-x)) and F(d-0.5) / (F(255.5-x) - F(-0.5-x)) are calculated, and the prediction difference d is encoded by the arithmetic encoding apparatus while assuming that the prediction difference d appears by the difference between two accumulation probabilities. Here, F(d) indicates the function which represents the integration of the probability density function p(d) of the Laplace distribution from $-\infty$ to d or indicates its similar function.

[0013]

With respect to the image decompression apparatus, the arithmetic decoding apparatus is used as the entropy decoder 16. The calculation method of the accumulation probability is same as that in the image compression apparatus. In the image compression apparatus and the image decompression apparatus, the updating of the variance $\sigma r^2$, which is performed for each encoded pixel, is performed after the encoding of the pixel. Incidentally, if there is two or more prediction difference data in which the dispersion index is r, the value of $\sigma r^2$ is set to r+1. Distribution function or the like, which is functionally approximated by normal distribution or least-square method, is used as the probability model, instead of Laplace distribution.

[0014]

[EXAMPLE4]

With respect to the image compression apparatus in the example 3, firstly, the final value of variance about all pixels is calculated without encoding and outputting, then, the final value is outputted as head of the compressed image data, and then, all pixels are encoded and outputted one by one with using the value of variance, instead of encoding while updating the variance for each pixel. With respect to the image decompression apparatus, firstly, variance is read, and then, all pixels are decoded one by one with using the value of variance.

[0015]

[EFFECT OF INVENTION]

In the case of claims 1 and 2, by selectively using the frequency distribution table depending on the value of the dispersion index, it is possible to eliminate the unnecessary increase of the encoded information amount due to the grouping of the frequency distributions whose aspects are different from each other in the Background Art. In the case of claims 3 and 4, by calculating variance for each dispersion index and controlling the calculation result of the probability density function for each dispersion index, it is possible to eliminate the unnecessary increase of the encoded information amount due to regarding the distributions whose aspects are different from each other as same one probability density function in the Background Art.

[Brief Description of Drawings]

[FIG. 1]

FIG. 1 shows one example of the present invention, and is a

block diagram of the image compression apparatus which encodes the prediction difference on the basis of the frequency distribution table selected on the basis of the dispersion index calculated from the reference pixel;

[FIG. 2]

FIG. 2 is a block diagram of the image decompression apparatus which decodes the prediction difference on the basis of the frequency distribution table selected on the basis of the dispersion index calculated from the reference pixel and obtains the gradation value of the decoded pixel by adding the decoded prediction difference to the prediction value;

[FIG. 3]

FIG. 3 shows a flow of the process of the image compression in the example shown in FIG. 1; and

[FIG. 4]

FIG. 4 shows a flow of the process of the image decompression in the example shown in FIG. 1.

[Description of the reference]

1 compression subject image data

2 image compression apparatus

3 controlling device

4 image data storing device

5 encoded pixel gradation value extracting device

6 reference pixel gradation value extracting device

7 prediction value calculating device

8 dispersion index calculating device

9 difference circuit

10 frequency distribution table selecting device

11 frequency distribution table updating device

12 frequency distribution table group

13 entropy encoder

14 compressed image data

15 image decompression apparatus

16 entropy decoder

17 adder

18 decompressed image data

FIG. 2

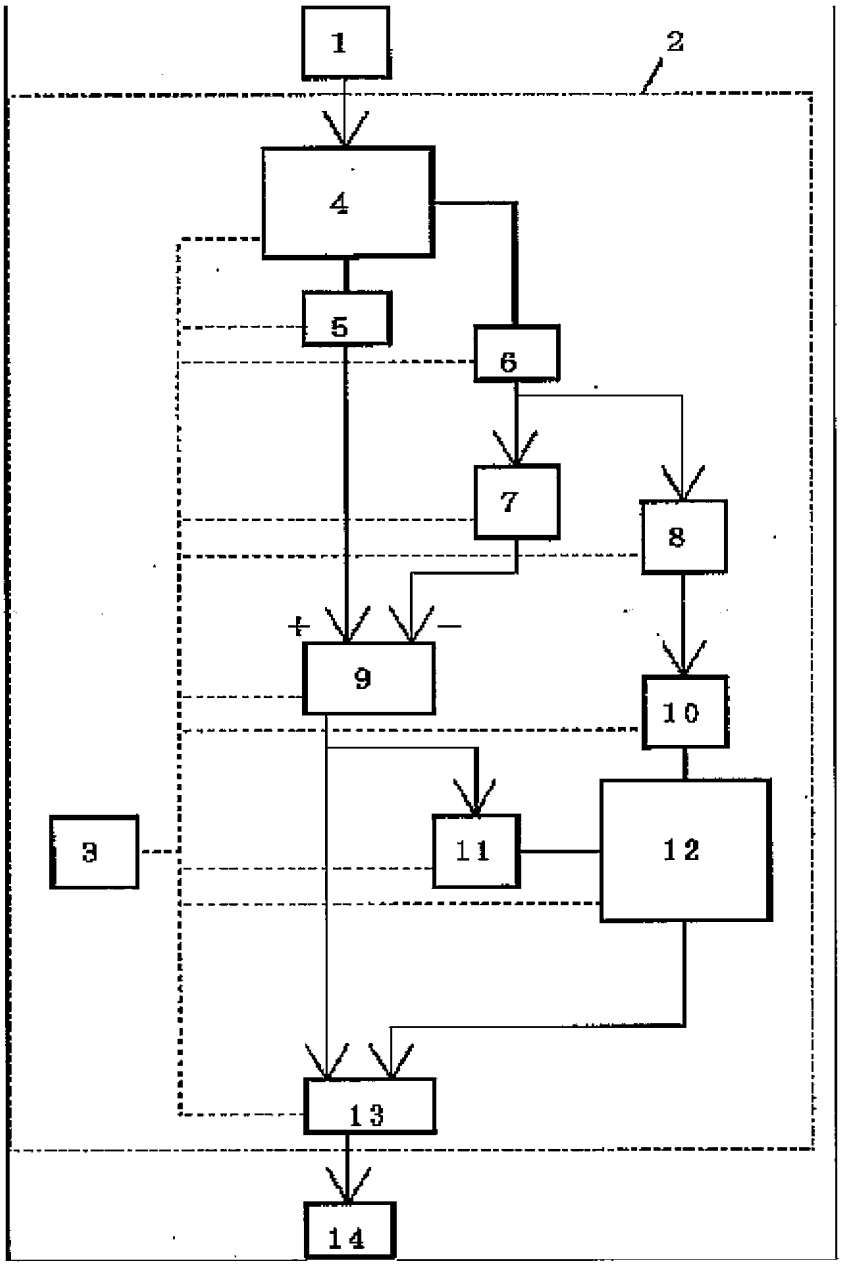


FIG. 2

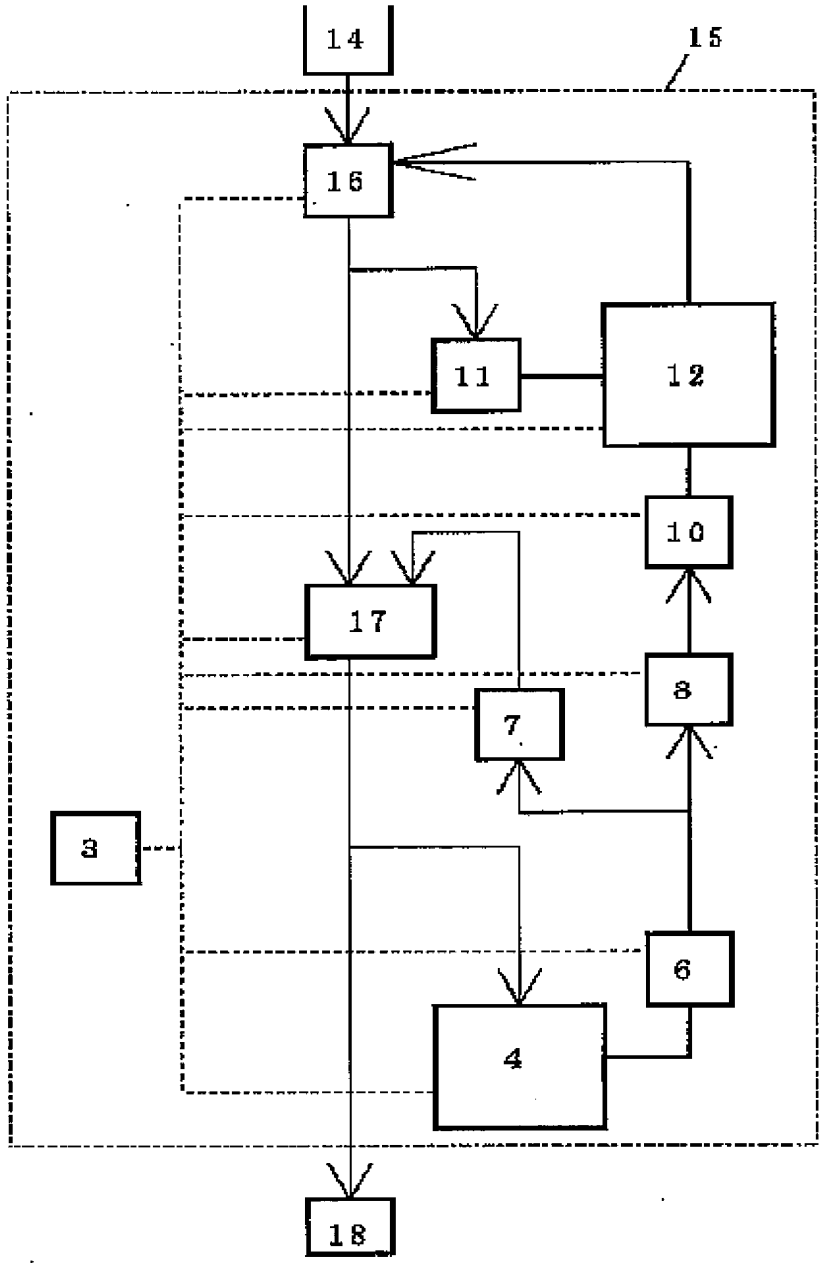


FIG. 3

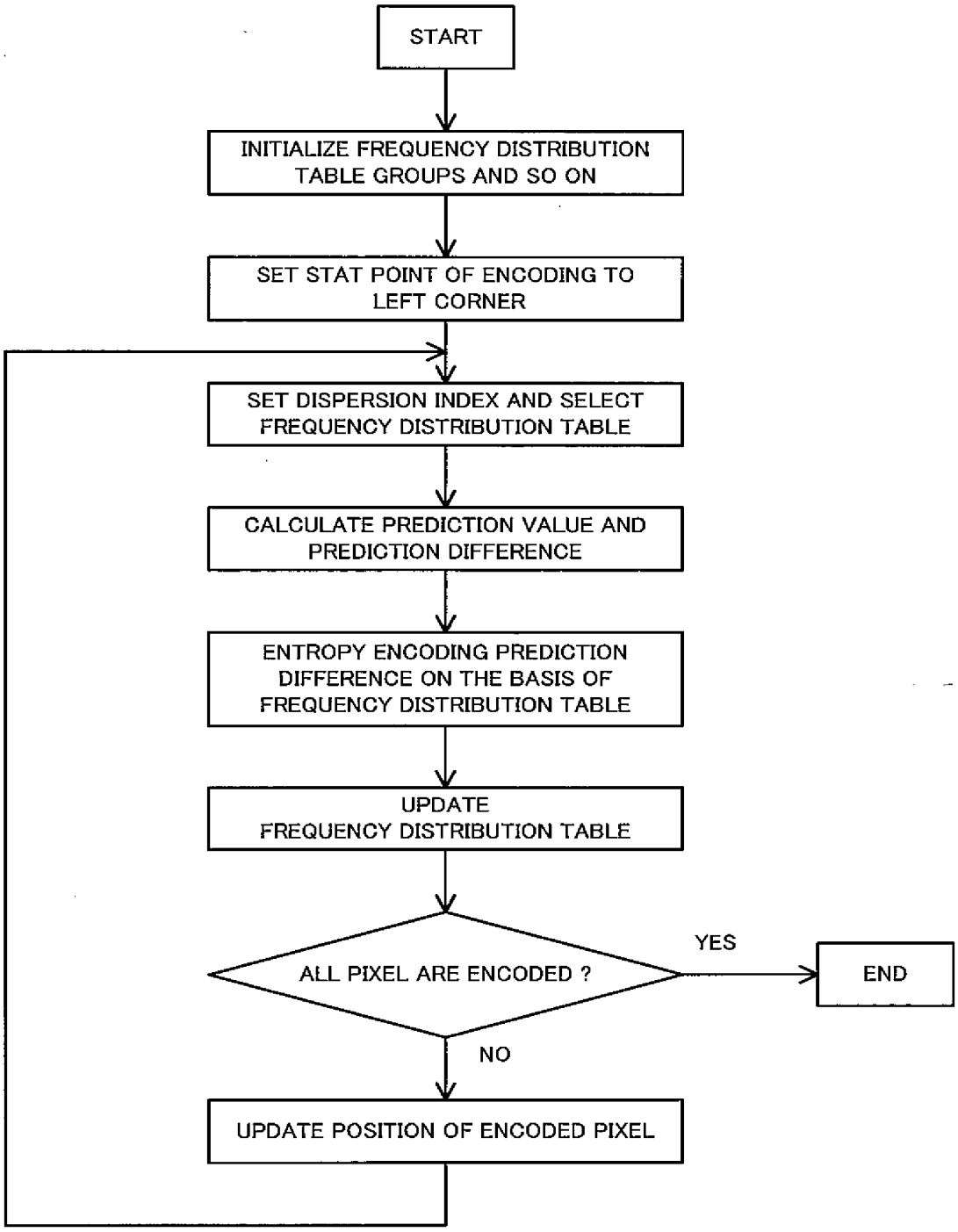
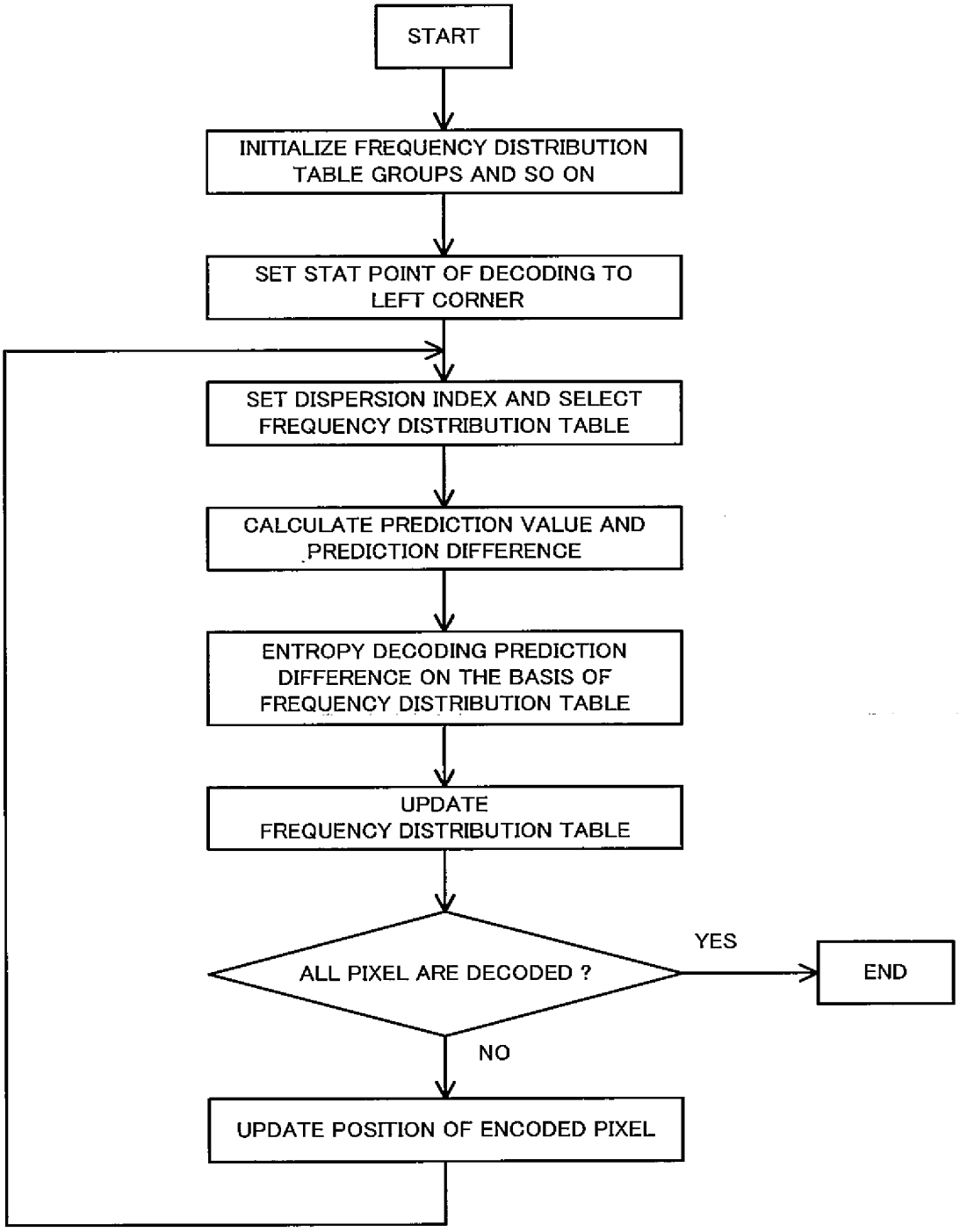

START
INITIALIZE FREQUENCY DISTRIBUTION TABLE GROUPS AND SO ON
SET STAT POINT OF ENCODING TO LEFT CORNER
SET DISPERSION INDEX AND SELECT FREQUENCY DISTRIBUTION TABLE
CALCULATE PREDICTION VALUE AND PREDICTION DIFFERENCE
ENTROPY ENCODING PREDICTION DIFFERENCE ON THE BASIS OF FREQUENCY DISTRIBUTION TABLE
UPDATE FREQUENCY DISTRIBUTION TABLE
ALL PIXEL ARE ENCODED ?
YES
END
NO
UPDATE POSITION OF ENCODED PIXEL

FIG. 4


START
INITIALIZE FREQUENCY DISTRIBUTION TABLE GROUPS AND SO ON
SET STAT POINT OF DECODING TO LEFT CORNER
SET DISPERSION INDEX AND SELECT FREQUENCY DISTRIBUTION TABLE
CALCULATE PREDICTION VALUE AND PREDICTION DIFFERENCE
ENTROPY DECODING PREDICTION DIFFERENCE ON THE BASIS OF FREQUENCY DISTRIBUTION TABLE
UPDATE FREQUENCY DISTRIBUTION TABLE
ALL PIXEL ARE DECODED ?
YES
END
NO
UPDATE POSITION OF ENCODED PIXEL